Opex econometric modelling

Prepared for Electricity Networks Aotearoa

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Executive summary

Background

The ENA has sought advice on key opex forecasting issues raised by the Commission in its DPP4 Issues Paper.[1] In particular, the ENA is seeking advice regarding:

- The opex regressions models used in the Issues Paper; and
- Their proposed use in the setting of opex allowances for EDBs over the DPP4 period and the implications for the EDBs.

These models are to be used to forecast opex over the DPP4 period, which will underpin the setting of opex allowances for EDBs under the DPP framework. Frontier Economics has been engaged to provide a report that analyses these models, their robustness, any shortcomings of the models, and the model outcomes.

We understand that the electricity sector in New Zealand is undergoing an evolution as the economy decarbonises. This includes the growing electrification of transport and process heat along with the increased uptake of solar PV and other distributed energy resources. This could mean that the historical relationship between opex and opex drivers may no longer hold well in future. This, in turn, may make reliable forecasting of opex growth challenging.

Key findings

We find that the analysis of the Commerce Commission has made two errors in relation to the peak demand variable considered for inclusion in the econometric models:

- The peak demand variable doubles the peak demand of several networks, a clear mistake in the construction of the variable; and
- The measure of demand should be ratcheted, so that demand measures the historical peak rather than the peak in a given year. Ratcheted maximum demand is in principle more closely linked to the capacity of the network.

We also find several shortcomings in the model selection approach used by the commission:

- The Commission considers a limited number of measures of model fit;

[1] Commerce Commission, Default price-quality paths for electricity distribution businesses from 1 April 2025 – Issues paper, November 2023.

- The Commission does not compare models using the same data sample;[2] and
- The Commission does not conduct an iterative process when selecting models and only allows for a single additional variable to be considered.

When these shortcomings are addressed, we find that the various alternative measures of peak demand do not improve the model fit and are therefore excluded from final models. We do find that a time trend should be added to the network opex model: the positive coefficient estimated may reflect an increase in regulatory obligations over time. This implies that the opex allowance should increase over time, all else remaining equal. For the non-network opex model we find that the time trend should be added, in addition to the capex measure.

While our results do not indicate that peak demand should be include on the basis of improvement in statistical fit, this should not be taken as evidence that demand has no effect on opex. This is because the explanatory variables in the Commission's opex models are highly correlated with one another. In these circumstances, the true effect of individual opex drivers on opex is difficult to estimate reliably. In our view, it would be economically meaningful to include ratcheted maximum demand as a driver of opex. This is consistent with the approach taken by the Australian Energy Regulator (AER).

Appendix B to this note provides some suggested text (based on the findings outlined above) for inclusion in the ENA's submission to the Commission.

Issues identified

Errors in deriving the peak demand for some EDBs

In the original dataset provided by the Commission, there was double counting in the reported peak demand for some EDBs due to the EDB-wide peak demand being added to the peak demands for the EDB's sub-networks. For example, in 2022 Vector reported maximum coincident demand of 1,807MW for the combined network, 1,138MW for the Southern network and 727MW for the Northern network. The peak demand in the dataset provided by the Commission was 3,673, the sum of the total network's peak and the two sub-networks' peak. This error also occurred for several other EDB, resulting in 18.3% of the observations in the 2013-2022 sample being affected.

[2] As set out in: Note on opex modelling in the DPP4 Issues paper, 30 November 2023.

Table 1: EDBs with overstated peak demand

EDB
Aurora Energy
Eastland Network
OtagoNet
Powerco
Unison Networks
Vector Lines

Source: Frontier Economics analysis of Commerce Commission and EDB data

Form of peak demand not aligned with application in other jurisdictions

The Commission has used maximum demand rather than ratcheted maximum demand in its model. Ratcheted maximum demand is commonly used by other regulators, such as the Australian Energy Regulator (AER), because it is an indication of the peak demand that the network has been built to deliver. There is general acceptance that ratcheted maximum demand drives capital investment in the network, which in turn is likely to drive opex (since more opex is required to maintain a larger network). Even if demand is unexpectedly low in a particular year, the network would have been built to satisfy the historical maximum demand.

The Commission used the maximum coincident system demand as its peak demand variable. In our view, non-coincident maximum demand would be a more meaningful driver of opex since the network needs to be maintained to a level that preserves the full non-coincident capacity of the system. We note that data on non-coincident maximum demand was formerly collected by the Commerce Commission, though we understand that this data is no longer collected by the Commission. Regardless, we consider it worthy of investigation.

To investigate the impact of using non-coincident versus coincident maximum demand, we have constructed a proxy for non-coincident maximum demand, which is equal to the peak demand reported for EDBs that only report data for a single network, and the maximum of the reported peak demand and the sum of the peak demands for the sub-networks for EDBs that report data for sub-networks (for example, for Vector we would use the sum of the peak demand of Vector Northern and Vector Southern). We note that the level of disaggregation in defining non-coincident maximum demand is often a subject of disagreement; our measure is at a very high level of aggregation compared to what is used in other jurisdictions: the AER for example uses non-coincident maximum demand at the transmission connection points for estimating the impact of demand on opex.

Time trend variables are not considered

The Commission does not include a time trend in the econometric model. In other jurisdictions, regulators include a time trend variable to control for time-related drivers of opex (e.g., technical

progress, changes in regulatory obligations, etc).[3] Such time trend variables, for example including the observation year in the regression as a variable, may also account for shortcomings in the price index applied to opex (and capex for specifications including capex). The omission of a time trend may mean that the sensitivity of opex to other cost drivers included in the Commission's model may be mis-estimated.

Reliance on limited model goodness-of-fit measures

The Commission uses adjusted R-squared and significance in evaluating model goodness-of-fit. We note that several other goodness-of-fit measures are available, the most commonly used measures alternative measures being the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). Like the adjusted R-squared measure, these goodness-of-fit measures both penalise the loss of degrees of freedom (i.e., reward parsimony), with the BIC penalising the inclusion of additional terms more heavily than the AIC.

For both these criteria, the specification with the lower value is considered to have the better fit, whereas for the adjusted R-squared measure the specification with the higher value is considered to have the best fit.

We note that significance of coefficients is reported in Tables D6 and D7 of the Issues Paper on the basis of ordinary standard errors rather than clustered standard errors (clustered at the EDB level). The Commission noted that adopting clustered standard errors can improve the accuracy of model selection.[4] We consider it appropriate to also consider significance using clustered standard errors, as the Commission appears to have done.

Iterative procedure required

The Commission's base model specifies customer numbers and line length as the drivers of opex, for both network opex and nonnetwork opex. As seen in Table D7 of the Issues Paper, the Commission has also evaluated whether peak demand, delivery and capex improve the model fit when examining drivers of non-network opex. The Commission finds that capex improves the model fit whereas peak demand and delivery do not. However, while demand and delivery may not improve the fit of a model with customer numbers and line length, they may improve the fit of a model with customer numbers, line length and capex. The Commission does not appear to perform this check. The selection of a preferred model should consider all combinations of potential drivers of opex to see which combination of variables provides the best fit and most plausible parameter estimates.

Limited post-estimation diagnostics

A standard technique used to check if an econometric model has been mis-specified is to plot the residuals from the model (i.e., the differences between actual opex and the fitted/predicted

[3] For example, the AER includes the observation year as a time trend variable in its econometric models. The AER considers that the measured time trend coefficient reflects, in part, an increase in regulatory obligations over time. See AER, *Draft Decision - Evoenergy Regulatory proposal 2024 to 2029 - Attachment 6 Operating expenditure*, p. 34.

[4] Commerce Commission, Default price-quality paths for electricity distribution businesses from 1 April 2025 – Issues paper, November 2023, p. 101.

opex values produced by the model). If the model is well-specified, there should be no discernible pattern in the residual plot (i.e., the plotted residuals would be distributed randomly).

This technique is straightforward, allowing for simple visual detection of possible specification issues.

Replication issues

While we were able to replicate Tables D4, D5 and the first three regressions in Table D6, we were unable to replicate the final regression in Table D6 and the entirety of Table D7 (restricting the sample to the same period of 2016-2022). We requested and received additional workings; the source of the discrepancy was attributed to the index used to deflate capex and the iterative vs fixed outlier exclusion method. We adopt an approach whereby capex is deflated by the same index used to deflate opex, and the iterative outlier exclusion procedure. We also use the full sample 2013-2022. That is, our starting point is the approach in the published code as set out in the note provided by the Commission.[5]

Refined approach

Changes to the Commission's approach

We retain the Commission's approach estimating the drivers of network opex and non-network opex separately. We have used the corrected peak demand for EDBs, i.e. not double counting the demand of Vector and other EDBs. We do this as the data used by the Commission is clearly inappropriate. We consider the inclusion of both the corrected peak demand variable "peak", and a constructed ratcheted peak demand variable "RMDemand". We also consider a simple non-coincident ratcheted maximum demand "RMDemandNC", by examining peak demand of sub-networks when available. We note that we commence the ratcheting procedure from 2009, the earliest data in the dataset relied upon by the Commission, rather than 2016, the first year of the samples used in Tables D6 and D7.[6]

We consider the inclusion of both a simple time trend (adding the year as a variable),[7] and a quadratic time trend (adding the year and year squared as additional variables).

Generally, all three goodness-of-fit criteria provide the same ordering of the fit of the models. Where they do not select the same preferred model, we evaluate model fit initially on the basis of BIC, though we also consider AIC, adjusted R-squared, and the sign and statistical significance of coefficients (statistical significance is measured by probability values, referred to as p-values, using both ordinary standard errors and clustered standard errors).

We note that AIC and BIC can only be used to compare models when the data is identical for all models being compared. That is, the same sample should be used for alternative specifications of the regression model. The Commission performs an outlier removal procedure. The Commission's modelling note suggests that the outlier removal procedure is applied to each

5 Note on opex modelling in the DPP4 Issues paper, 30 November 2023.

6 This follows the approach taken by the AER – the short (2012 onwards) samples using the same value of ratcheted maximum demand as in the long (2006 onwards) samples.

7 For presentation purposes we use a variable *t* defined as the year minus 2013.

alternative model specification.[8] This could lead to different observations being removed for different model specifications, making a comparison of model fit using the AIC and BIC criteria invalid. To avoid this problem, we use the Commission's procedure to determine which observations are outliers for the base model (with only customer numbers and circuit length as drivers), and exclude these same outliers from the sample used to estimate all the alternative model specifications. That is, we use a common sample for all the model specifications. After determining our preferred model on this common sample, we then repeat the outlier removal procedure for the preferred model.

To summarise, we perform several post-estimation diagnostic techniques. These are:

- Residual plots
- Plausibility of coefficient estimates
- Considering the impact of clustered standard errors on the significance of the variables
- Repeating the outlier removal procedure using the candidate specification and checking for inclusion of variables

Results

Network opex

We start with the base specification – explaining real network opex using ICP (customer numbers) and line length using the 2013-2022 sample. After removing outliers we are left with a sample of 287 observations. The results from each of the initial alternative specifications is shown Table 5 in the Appendix. From the alternatives we select the specification with a time trend – the time trend is significant even when using clustered standard errors, and this specification has the highest adjusted R-squared and lowest (best) AIC and BIC.

In the second stage, we continue refining the model by adding additional variables to the base plus time trend model. That is, we consider a model with customer numbers, line length and a time trend, and investigate if any further additional variables should be added. The results are shown in Table 6. The table shows that only the specification with capex is suggested to be an improvement on the basis of adjusted R-squared and AIC,[9] though we note that that specification has a worse BIC, the capex variable is insignificant when using clustered standard errors and the sign is negative. We therefore retain the specification that adds only the time trend to the base model.

In the final stage we undertake the outlier procedure for this model and re-estimate this model and all the models in the previous stage after excluding the additional outliers. The results are reported in Table 7. With this slightly smaller sample, the specification with capex is an improvement on the base model plus time trend specification based on the adjusted R-squared, AIC and BIC, but the capex variable is still insignificant when using clustered standard errors and

[8] Note on opex modelling in the DPP4 Issues paper, 30 November 2023.

[9] The AIC for this model is 67.34, which is less than 70.98 – the AIC for the model with customer numbers, line length and the time trend.

the sign is negative. We therefore retain the specification that only adds the time trend to the base model.

The results for the final specification are:

Table 2: Final network opex specification

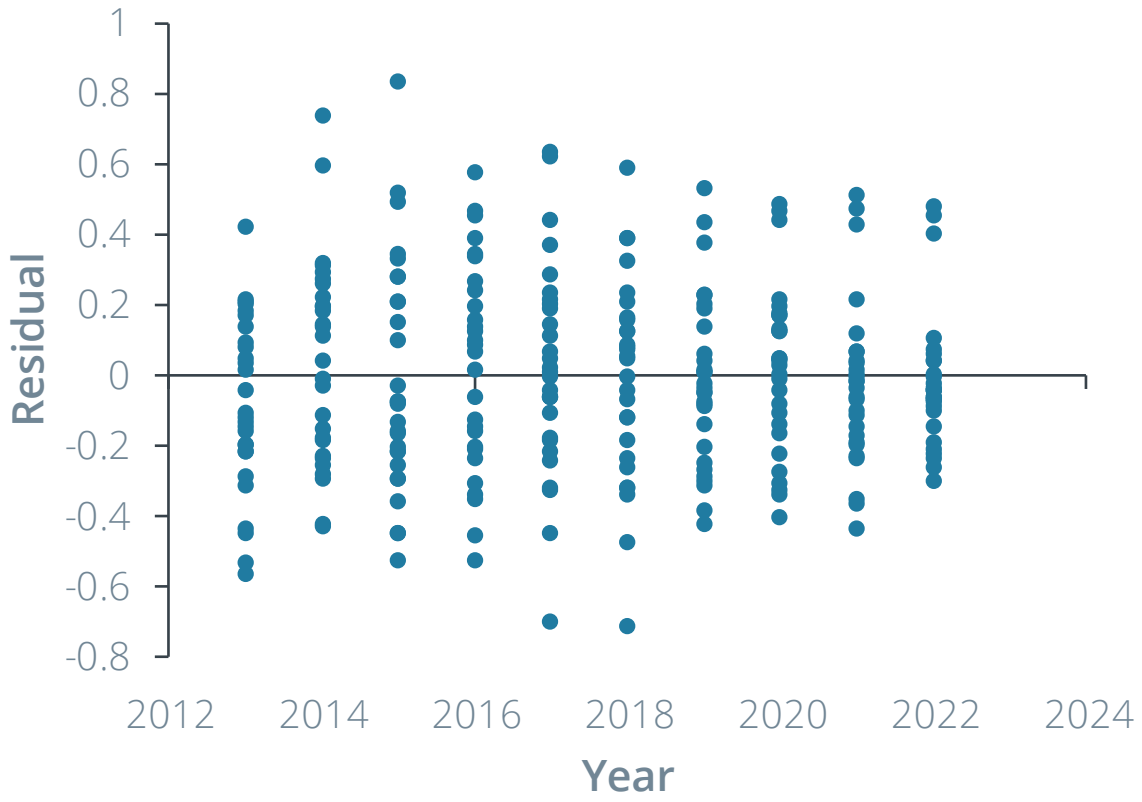
	Coefficient	Significance	Significance (clustered SE)
Constant	-0.287	6.8%	38.2%
ICP	0.448	0.0%	0.0%
Lines	0.499	0.0%	0.0%
Time	0.022	0.0%	0.0%
N	283		
R2	92.18%		
Adjusted R2	92.09%		
AIC	62.81		
BIC	81.04		

Source: Frontier Economics analysis of Commerce Commission and EDB data

Note: Significance is measured by the p-value, with values less than 5% considered to be statistically significant.

The residuals for the final specification show now apparent pattern when plotted over time, shown in Figure 1.

Figure 1: Residuals for the final network opex specification



Source: Frontier Economics analysis of Commerce Commission and EDB data

We note that none of the three measures of peak demand have been selected for inclusion in the final specification. Further, the coefficients on the demand variables are negative, though statistically insignificant. This is clearly problematic for forecasting opex in an environment where peak demand is expected to increase over time. These models would be rejected by the AER on the basis that it is a violation of the 'monotonicity property' that an increase in output can only be achieved with an increase in inputs, holding other things constant.[10] This is not to say that the true effect is negative, or zero; rather the correlation with other variables included in the model make it challenging to estimate the impact of this variable. We note that ENA members may wish to propose to the Commission an approach whereby the impact of demand is assumed, perhaps from regulatory precedent or bottom-up approaches.

If we were to take the final specification as in Table 2 above, and add ratcheted maximum non-coincident demand, imposing an elasticity of 30% for example, the following estimates are obtained:

10 AER, Annual Benchmarking Report - Electricity distribution network service providers, November 2023, p.47.

Table 3: Alternative network opex specification – imposed coefficient on ratcheted peak demand

	Coefficient	Significance	Significance (clustered SE)
Constant	1.446	0.0%	0.0%
ICP	0.164	0.0%	0.6%
Lines	0.478	0.0%	0.0%
Time	0.021	0.0%	0.0%
RMDemandNC	0.300	n/a	n/a
N	283		

Source: Frontier Economics analysis of Commerce Commission and EDB data

Note: Significance is measured by the p-value, with values less than 5% considered to be statistically significant.

Non-network opex

We start with the base specification – explaining real non-network opex using ICP and lines for the 2013-2022 sample. After removing outliers we are left with a sample of 283 observations. The results from each of the initial alternative specifications is shown in Table 8. From the alternatives we select the specification that adds capex to the base model – this variable is significant even when using clustered standard errors, and this specification has the highest adjusted R-squared and lowest (best) AIC and BIC.

In the second stage, we continue refining the model by considering additional variables. The results are shown in Table 9. The table suggests that the specification with the time trend is an improvement. We therefore adopt the specification that adds capex and the time trend.

Next, in the third stage, we consider adding additional variables. As shown in Table 10 no alternative model with additional variables is suggested to be improvement on the base specification with the addition of capex and the time trend. We therefore retain this specification as the preferred specification.

In the final stage we undertake the outlier procedure for this model and re-estimate this model and all the models in the previous stage after excluding the additional outliers. The results are shown in Table 11. With this slightly smaller larger sample the specification with capex and time trend is found to be the best specification on the basis of the adjusted R-squared, AIC and BIC and significance (using both standard and clustered standard errors). We therefore retain the specification that adds capex and the time trend to the base model.

The results for the final specification are:

Table 4**:** Final non-network opex specification

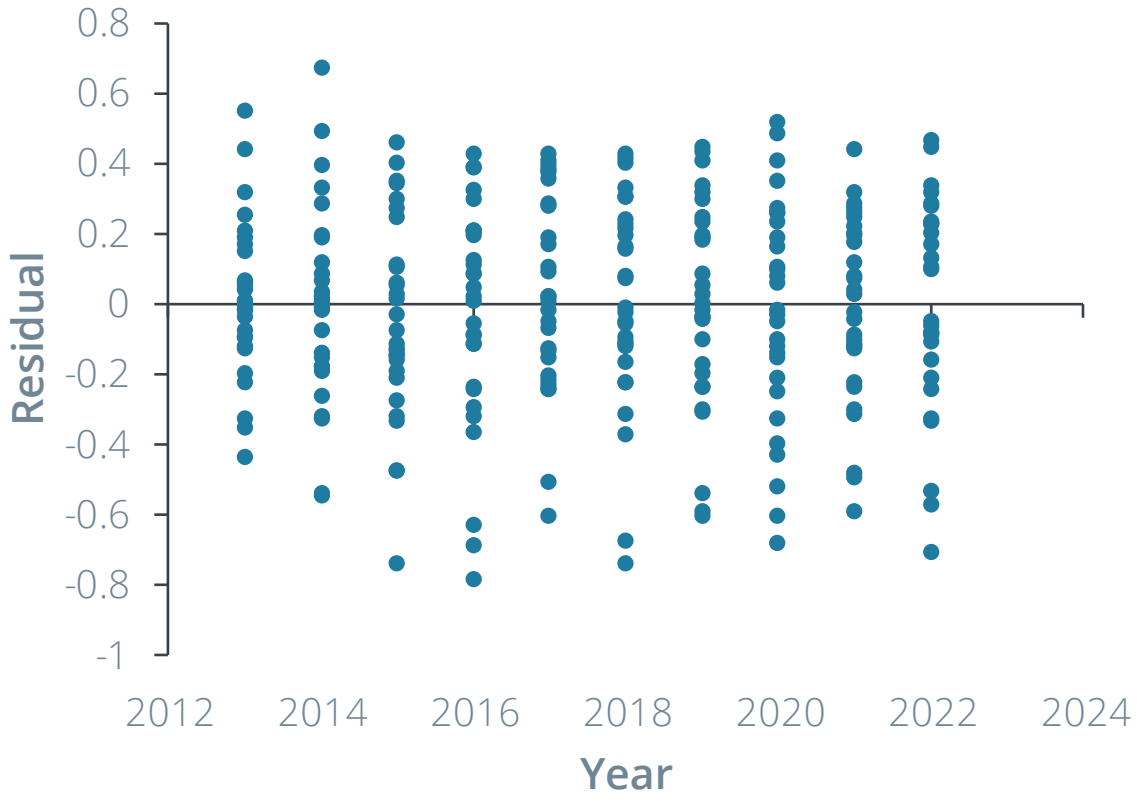
	Coefficient	Significance	Significance (clustered SE)
Constant	0.552	0.2%	14.3%
ICP	0.494	0.0%	0.0%
Lines	0.145	0.0%	18.0%
Capex	0.200	0.0%	1.4%
Time	0.021	0.0%	0.2%
N	286		
R2	90.99%		
Adjusted R2	90.86%		
AIC	105.26		
BIC	127.20		

Source: Frontier Economics analysis of Commerce Commission and EDB data

Note: Significance is measured by the p-value, with values less than 5% considered to be statistically significant.

The residuals for the final specification are shown in Figure 2. The figure shows no apparent pattern over time.

Figure 2: Residuals for final non-network opex specification



Source: Frontier Economics analysis of Commerce Commission and EDB data

Appendix A

Table 5**:** Network opex: First stage – base model includes ICP and lines

	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.
Constant	-0.197	20.9%	55.5%	-0.335	37.4%	63.0%	-0.100	75.2%	87.9%	-0.268	9.5%	35.1%	-0.277	7.6%	41.6%	-0.299	5.8%	38.5%	-0.289	43.6%	68.2%	-0.263	48.1%	71.6%
ICP	0.443	0.0%	0.0%	0.465	0.0%	0.0%	0.423	0.0%	0.2%	0.487	0.0%	0.0%	0.440	0.0%	0.0%	0.441	0.0%	0.0%	0.458	0.0%	0.0%	0.453	0.0%	0.1%
Lines	0.508	0.0%	0.0%	0.509	0.0%	0.0%	0.503	0.0%	0.0%	0.539	0.0%	0.0%	0.510	0.0%	0.0%	0.509	0.0%	0.0%	0.509	0.0%	0.0%	0.508	0.0%	0.0%
Peak				-0.024	68.8%	82.0%																		
Delivery							0.023	72.0%	83.8%															
Capex										-0.067	5.6%	48.1%												
Time													0.020	0.0%	0.0%	0.037	7.0%	3.4%						
TimeSquared																-0.002	36.9%	21.8%						
RMDemand																			-0.016	78.5%	87.9%			
RMDemandNC																						-0.011	84.6%	91.6%
N	287			287			287			287			287			287			287			287		
R2	91.88%			91.88%			91.88%			91.98%			92.22%			92.24%			91.88%			91.88%		
Adjusted R2	91.82%			91.80%			91.80%			91.90%			92.14%			92.13%			91.80%			91.79%		
AIC	81.30			83.14			83.17			79.59			70.98			72.16			83.23			83.27		
BIC	95.9			101.4			101.5			97.9			89.3			94.1			101.5			101.6		

Source: Frontier Economics analysis of Commerce Commission and EDB data

Note: Significance is measured by the p-value, with values less than 5% considered to be statistically significant.

Table 6**:** Network opex: Second stage – all models include ICP, lines and time trend

	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.
Constant	-0.277	7.6%	41.6%	-0.446	22.9%	51.9%	-0.144	64.1%	82.8%	-0.368	2.1%	21.0%	-0.299	5.8%	38.5%	-0.404	27.0%	56.7%	-0.379	30.4%	60.0%
ICP	0.440	0.0%	0.0%	0.468	0.0%	0.0%	0.413	0.0%	0.2%	0.494	0.0%	0.0%	0.441	0.0%	0.0%	0.461	0.0%	0.0%	0.457	0.0%	0.0%
Lines	0.510	0.0%	0.0%	0.511	0.0%	0.0%	0.504	0.0%	0.0%	0.548	0.0%	0.0%	0.509	0.0%	0.0%	0.511	0.0%	0.0%	0.511	0.0%	0.0%
Peak				-0.030	61.5%	77.6%															
Delivery							0.032	61.8%	78.4%												
Capex										-0.082	1.9%	38.4%									
Time	0.020	0.0%	0.0%	0.020	0.0%	0.0%	0.020	0.0%	0.0%	0.021	0.0%	0.0%	0.037	7.0%	3.4%	0.020	0.0%	0.0%	0.020	0.0%	0.0%
TimeSquared													-0.002	36.9%	21.8%						
RMDemand																-0.022	70.1%	83.2%			
RMDemandNC																			-0.018	76.0%	86.9%
N	287			287			287			287			287			287			287		
R2	92.22%			92.23%			92.23%			92.37%			92.24%			92.22%			92.22%		
Adjusted R2	92.14%			92.12%			92.12%			92.26%			92.13%			92.11%			92.11%		
AIC	70.98			72.72			72.73			67.34			72.16			72.83			72.89		
BIC	89.28			94.68			94.68			89.29			94.12			94.79			94.84		

Source: Frontier Economics analysis of Commerce Commission and EDB data

Note: Significance is measured by the p-value, with values less than 5% considered to be statistically significant.

Table 7**:** Network opex: Third stage – all models include ICP, lines and time trend; excluding outliers from sample

	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.
Constant	-0.287	6.8%	38.2%	-0.480	19.7%	47.4%	-0.170	58.6%	79.1%	-0.407	1.2%	16.4%	-0.317	4.6%	33.3%	-0.433	23.7%	52.6%	-0.407	26.9%	56.0%
ICP	0.448	0.0%	0.0%	0.479	0.0%	0.0%	0.424	0.0%	0.1%	0.512	0.0%	0.0%	0.449	0.0%	0.0%	0.472	0.0%	0.0%	0.468	0.0%	0.0%
Lines	0.499	0.0%	0.0%	0.502	0.0%	0.0%	0.494	0.0%	0.0%	0.549	0.0%	0.0%	0.498	0.0%	0.0%	0.501	0.0%	0.0%	0.501	0.0%	0.0%
Peak				-0.033	56.6%	74.1%															
Delivery							0.028	66.4%	80.8%												
Capex										-0.100	0.5%	28.3%									
Time	0.022	0.0%	0.0%	0.022	0.0%	0.0%	0.022	0.0%	0.0%	0.024	0.0%	0.0%	0.046	2.5%	1.3%	0.022	0.0%	0.0%	0.022	0.0%	0.0%
TimeSquared													-0.003	22.6%	11.9%						
RMDemand																-0.025	65.8%	80.3%			
RMDemandNC																			-0.021	71.7%	84.2%
N	283			283			283			283			283			283			283		
R2	92.18%			92.18%			92.18%			92.39%			92.22%			92.18%			92.18%		
Adjusted R2	92.09%			92.07%			92.07%			92.28%			92.10%			92.07%			92.07%		
AIC	62.81			64.47			64.62			56.84			63.31			64.61			64.68		
BIC	81.04			86.35			86.49			78.71			85.19			86.48			86.55		

Source: Frontier Economics analysis of Commerce Commission and EDB data

Note: Significance is measured by the p-value, with values less than 5% considered to be statistically significant.

Table 8**:** Nonnetwork opex: First stage – base model includes ICP and lines

	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.
Constant	0.393	2.2%	28.0%	1.105	0.7%	31.3%	0.626	6.9%	51.6%	0.629	0.0%	9.4%	0.301	7.3%	39.5%	0.309	7.1%	38.3%	1.160	0.4%	27.1%	1.178	0.4%	26.4%
ICP	0.599	0.0%	0.0%	0.478	0.0%	3.2%	0.550	0.0%	1.9%	0.464	0.0%	0.0%	0.601	0.0%	0.0%	0.601	0.0%	0.0%	0.468	0.0%	3.0%	0.465	0.0%	3.0%
Lines	0.279	0.0%	0.6%	0.275	0.0%	0.8%	0.270	0.0%	0.6%	0.182	0.0%	6.6%	0.274	0.0%	0.7%	0.274	0.0%	0.7%	0.274	0.0%	0.8%	0.274	0.0%	0.8%
Peak				0.125	5.5%	49.7%																		
Delivery							0.056	43.3%	79.0%															
Capex										0.204	0.0%	0.9%												
Time													0.025	0.0%	0.1%	0.019	38.6%	6.8%						
TimeSquared																0.001	80.2%	57.0%						
RMDemand																			0.136	3.5%	44.6%			
RMDemandNC																						0.138	3.2%	43.6%
N	283			283			283			283			283			283			283			283		
R2	90.09%			90.22%			90.11%			91.12%			90.66%			90.66%			90.25%			90.25%		
Adjusted R2	90.02%			90.12%			90.01%			91.03%			90.56%			90.52%			90.14%			90.15%		
AIC	127.3			125.6			128.7			98.3			112.8			114.7			124.8			124.7		
BIC	141.9			143.8			146.9			116.5			131.0			136.6			143.1			142.9		

Source: Frontier Economics analysis of Commerce Commission and EDB data

Note: Significance is measured by the p-value, with values less than 5% considered to be statistically significant.

Opex econometric modelling

Table 9: Nonnetwork opex: Second stage – all models include ICP, lines and capex

	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.	Coef.	Sig.	Clust. Sig.
Constant	0.629	0.0%	9.4%	0.760	5.4%	43.0%	0.533	10.3%	52.4%	0.533	0.1%	14.9%	0.527	0.2%	15.3%	0.834	3.2%	36.8%	0.848	3.0%	35.9%
ICP	0.464	0.0%	0.0%	0.444	0.0%	2.9%	0.483	0.0%	2.6%	0.477	0.0%	0.0%	0.476	0.0%	0.0%	0.432	0.0%	2.8%	0.430	0.0%	2.9%
Lines	0.182	0.0%	6.6%	0.183	0.0%	7.3%	0.184	0.0%	5.0%	0.185	0.0%	5.7%	0.185	0.0%	5.7%	0.183	0.0%	7.3%	0.183	0.0%	7.3%
Peak				0.024	71.3%	88.5%															
Delivery							-0.024	73.2%	89.3%												
Capex	0.204	0.0%	0.9%	0.200	0.0%	1.2%	0.207	0.0%	0.7%	0.188	0.0%	1.4%	0.188	0.0%	1.4%	0.198	0.0%	1.3%	0.197	0.0%	1.3%
Time										0.021	0.0%	0.3%	0.025	23.8%	2.3%						
TimeSquared													-0.001	82.6%	63.8%						
RMDemand																0.038	55.7%	81.3%			
RMDemandNC																			0.040	53.3%	80.0%
N	283			283			283			283			283			283			283		
R2	91.12%			91.13%			91.13%			91.51%			91.51%			91.13%			91.14%		
Adjusted R2	91.03%			91.00%			91.00%			91.39%			91.36%			91.01%			91.01%		
AIC	98.3			100.1			100.1			87.6			89.6			99.9			99.9		
BIC	116.5			122.0			122.0			109.5			115.1			121.8			121.7		

Source: Frontier Economics analysis of Commerce Commission and EDB data

Note: Significance is measured by the p-value, with values less than 5% considered to be statistically significant.

Table 10: Nonnetwork opex: Third stage – all models include ICP, lines, capex and time trend

	Coef.	Sig.	Clust.Sig.	Coef.	Sig.	Clust.Sig.	Coef.	Sig.	Clust.Sig.	Coef.	Sig.	Clust.Sig.	Coef.	Sig.	Clust.Sig.	Coef.	Sig.	Clust.Sig.
Constant	0.533	0.1%	14.9%	0.690	7.5%	48.0%	0.511	11.1%	54.2%	0.527	0.2%	15.3%	0.758	4.7%	42.0%	0.772	4.4%	41.2%
ICP	0.477	0.0%	0.0%	0.452	0.0%	2.9%	0.481	0.0%	2.8%	0.476	0.0%	0.0%	0.442	0.0%	2.7%	0.440	0.0%	2.8%
Lines	0.185	0.0%	5.7%	0.187	0.0%	6.4%	0.186	0.0%	4.5%	0.185	0.0%	5.7%	0.187	0.0%	6.3%	0.187	0.0%	6.3%
Peak				0.029	65.2%	86.4%												
Delivery							-0.005	93.7%	97.6%									
Capex	0.188	0.0%	1.4%	0.183	0.0%	1.7%	0.188	0.0%	1.1%	0.188	0.0%	1.4%	0.181	0.0%	1.9%	0.180	0.0%	1.9%
Time	0.021	0.0%	0.3%	0.021	0.0%	0.3%	0.021	0.0%	0.5%	0.025	23.8%	2.3%	0.021	0.0%	0.3%	0.021	0.0%	0.3%
TimeSquared										-0.001	82.6%	63.8%						
RMDemand													0.041	51.0%	79.9%			
RMDemandNC																0.044	48.8%	78.7%
N	283			283			283			283			283			283		
R2	91.51%			91.52%			91.51%			91.51%			91.52%			91.53%		
Adjusted R2	91.39%			91.36%			91.36%			91.36%			91.37%			91.37%		
AIC	87.61			89.41			89.61			89.57			89.17			89.12		
BIC	109.49			114.92			115.13			115.08			114.69			114.64		

Source: Frontier Economics analysis of Commerce Commission and EDB data

Note: Significance is measured by the p-value, with values less than 5% considered to be statistically significant.

Table 11: Nonnetwork opex: Fourth stage – all models include ICP, lines, capex and time trend; excluding outliers from sample

	Coef.	Sig.	Clust.Sig.	Coef.	Sig.	Clust.Sig.	Coef.	Sig.	Clust.Sig.	Coef.	Sig.	Clust.Sig.	Coef.	Sig.	Clust.Sig.	Coef.	Sig.	Clust.Sig.
Constant	0.552	0.2%	14.3%	0.558	15.9%	59.8%	0.413	20.8%	64.3%	0.554	0.2%	14.0%	0.634	10.5%	53.4%	0.647	10.0%	52.5%
ICP	0.494	0.0%	0.0%	0.493	0.0%	3.0%	0.521	0.0%	2.6%	0.494	0.0%	0.0%	0.481	0.0%	2.9%	0.479	0.0%	2.9%
Lines	0.145	0.0%	18.0%	0.145	0.0%	19.2%	0.149	0.0%	14.6%	0.145	0.0%	17.9%	0.146	0.0%	19.1%	0.146	0.0%	19.1%
Peak				0.001	98.5%	99.5%												
Delivery							-0.035	61.7%	85.4%									
Capex	0.200	0.0%	1.4%	0.200	0.0%	1.4%	0.204	0.0%	1.0%	0.200	0.0%	1.4%	0.197	0.0%	1.6%	0.197	0.0%	1.6%
Time	0.021	0.0%	0.2%	0.021	0.0%	0.3%	0.021	0.1%	0.4%	0.019	38.6%	11.7%	0.021	0.0%	0.2%	0.021	0.0%	0.2%
TimeSquared										0.000	92.1%	84.1%						
RMDemand													0.015	81.4%	93.1%			
RMDemandNC																0.018	78.6%	91.9%
N	286			286			286			286			286			286		
R2	90.99%			90.99%			91.00%			90.99%			90.99%			90.99%		
Adjusted R2	90.86%			90.83%			90.84%			90.83%			90.83%			90.83%		
AIC	105.26			107.26			107.01			107.25			107.21			107.19		
BIC	127.20			132.86			132.60			132.85			132.80			132.78		

Source: Frontier Economics analysis of Commerce Commission and EDB data

Note: Significance is measured by the p-value, with values less than 5% considered to be statistically significant.

Appendix B – overview of findings

A review of the approach of the Commerce Commission has identified several concerns related to the construction of the peak demand variable and the model selection process employed.

In constructing the peak demand variable, it appears that the Commission has summed the peak demand of the EDB along with the peak demand of smaller network components. As an example, for Vector the Commission has added the combined peak demand (1,807 MW) with the peak demand for the Northern network (727 MW) and the Southern network (1,138 MW) to obtain 3,673 MW, approximately double the correct peak demand.

Further, while the Commission uses the annual peak demand as per the information disclosure data, it is more appropriate to use the ratcheted maximum demand, so that demand measures the historical peak rather than the peak in given year. Ratcheted maximum demand is commonly used by regulators such as the Australian Energy Regulator (AER), because it is an indication of the peak demand that the network has been built to deliver. Even if demand is unexpectedly low in a particular year, the network would have been built to satisfy the historical maximum demand.

While disclosure data only contains information on coincident peak demand, non-coincident maximum demand may be a more relevant driver of opex. We note that the level of disaggregation in defining non-coincident maximum demand is often a subject of disagreement.

We investigated the impact of the corrected peak demand variable, as well as a ratcheted maximum demand as a possible opex driver. We also consider inclusion of a time trend, as applied in the AER's econometric models used to derive output weights.

We find that the various alternative measures of peak demand, including ratcheted maximum demand, do not improve the model fit and are therefore excluded from final models. However, we note that due to the high degree of correlation between opex drivers in the Commission's models, it is difficult for the model to estimate the effect of individual cost drivers accurately. Therefore, the fact that peak demand does not appear to improve model fit does not mean that it is an irrelevant explanator of opex.

We do find that a time trend should be added to the network opex model: the positive coefficient estimated may reflect an increase in regulatory obligations over time. For the non-network opex model we find that the time trend should be added, in addition to the capex measure.

We also find several shortcomings in the model selection approach used by the commission.

- The Commission does not consider the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), commonly used measures of goodness-of-fit. These measures are commonly used in model selection. The Commission should consider the use of these additional model selection criteria.

- The Commission does not appear to compare models using the same data sample.[11] In comparing alternative models using goodness of fit, it is crucial to evaluate the models on a consistent basis using the same observations. If models estimated using different specifications and different samples are compared, it will be unclear whether a particular model is favoured due to its particular specification or simply because it is estimated using a different sample.
- The Commission does not conduct an iterative process to model selection and only allows for a single additional variable to be considered. For example, when capex is selected in the non-network opex model the Commission should continue and evaluate whether demand or delivery further improve model fit.

[11] As set out in: Note on opex modelling in the DPP4 Issues paper, 30 November 2023.

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Frontier Economics

Brisbane | Melbourne | Singapore | Sydney

Frontier Economics Pty Ltd
395 Collins Street Melbourne Victoria 3000

Tel: [redacted]
https://www.frontier-economics.com.au

ACN: 087 553 124 ABN: 13 087 553 124